

Maine Department of  
Transportation  
**Transportation Research  
Division**



**Technical Report 92-34**

*Field Trial of Gravel Stabilization Methods*

*Route 1, Cyr - Van Buren, Maine*

*Eighth Interim Report, April 2004*

# Transportation Research Division

## *Field Trial of Gravel Stabilization Methods*

### *Route 1, Cyr - Van Buren, Maine*

#### **Introduction**

This experimental construction project was developed, designed, and inspected by personnel from the University of Maine, Civil Engineering Staff. The project was constructed on and as a part of Project Number 2586.00 in Cyr Plantation - Van Buren (see Figure 1).

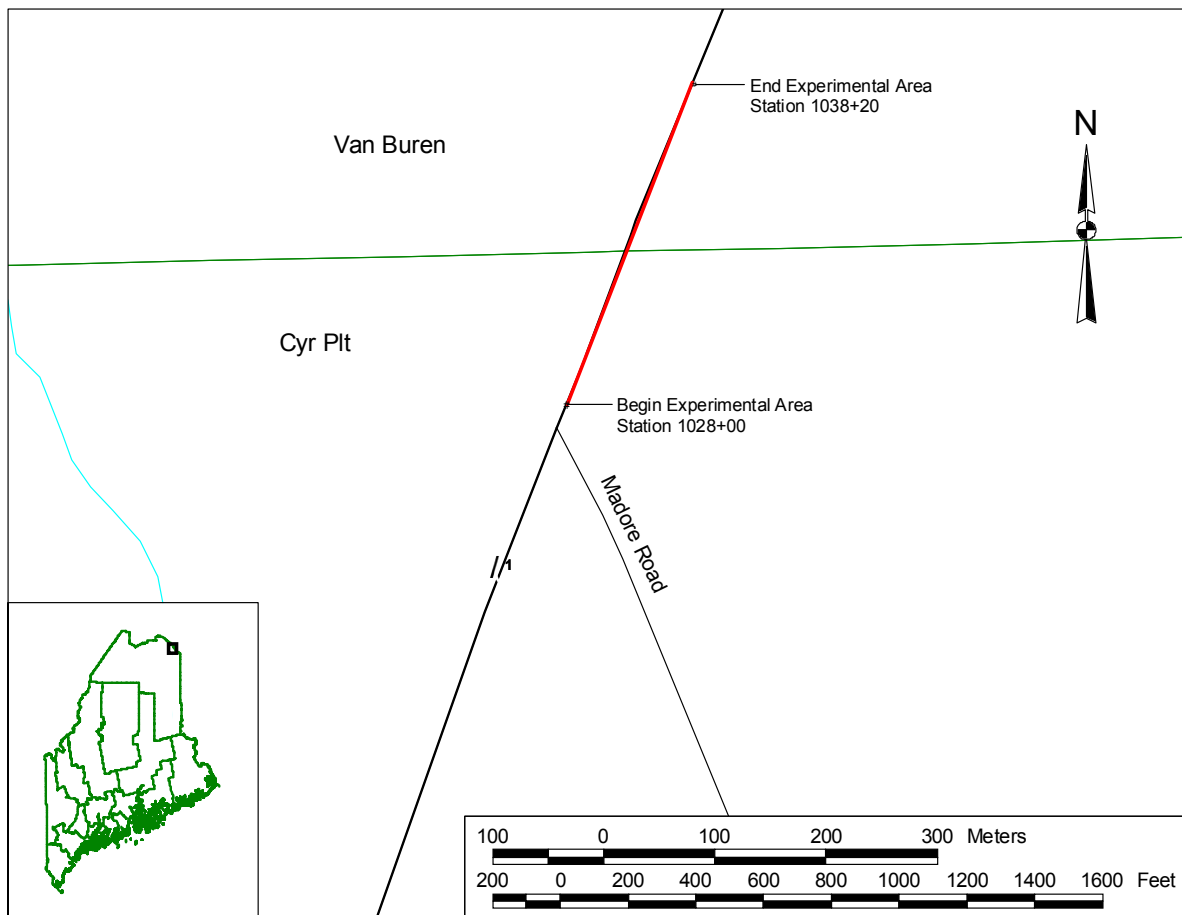


Figure 1. Project Location Map

This was a complete reconstruction project 2.2 miles (3.5 kilometers) in length. The experimental section contains 6 experimental base types and is 1020 feet (311 meters) in length. The experimental section began at Station 1028+00 and ended at Station 1038+20. The test section consisted of 200 foot (61 meter) segments of soil cement, asphalt, calcium chloride, modified, standard and one 20 foot (6 meter) untreated section. The stabilized and control sections were located as follows:

Soil Cement Stabilized	Station 1028+00 to 1030+00
Modified Subbase Control	Station 1030+00 to 1032+00
Asphalt Stabilized	Station 1032+00 to 1034+00
Untreated Section	Station 1034+00 to 1034+20
Calcium Chloride Stabilized	Station 1034+20 to 1036+20
Standard Subbase Control	Station 1036+20 to 1038+20

The Soil Cement Stabilized section is a mixture of Modified Subbase (mentioned later) and 6 percent by weight of Type I Portland Cement.

The Modified Subbase Control section is standard subbase aggregate MDOT specification 703.06b Type D with a 2 inch (51 mm) maximum aggregate size. This aggregate was used on all stabilized sections to facilitate blending of each treatment.

The Asphalt Stabilized section is a mixture of Modified Subbase and 4.5 percent of MS-4 Emulsified Asphalt.

The Untreated section consists of Modified Subbase.

The Calcium Chloride Stabilized section is a mixture of Modified Subbase and 0.75 gal/yd<sup>2</sup> (3.4 L/m<sup>2</sup>) of 35 percent liquid calcium chloride solution.

The Standard Subbase Control section consists of standard subbase aggregate MDOT specification 703.06b Type D with a 6 inch maximum aggregate size.

Construction on this project started in September 1990 and was completed in the summer of 1991. A background of the stabilization agents, their uses, advantages and disadvantages is explained in the MDOT construction report titled "Field Trial of Gravel Stabilization Methods", Experimental Construction Report 92-34, printed December 1991. This report also provided preliminary design results as well as test results obtained during construction. In addition to the test results, a plan for long term monitoring was also included in Appendix G and reproduced for this report in Table 1. Some of the features to be monitored are rutting and serviceability, such as roughness and overall performance. Strength measurements using pavement deflection was also suggested. Most of the evaluations can be performed with the Automatic Road Analyzer and Falling Weight Deflectometer test vehicles. Long term monitoring of the calcium chloride is specifically mentioned. For this phase they recommend boring test holes and sampling the base every 5th year to monitor the possibility of leaching calcium chloride.

## Project Evaluation

This report covers the period of time from January 2002 thru December 2003.

Table 1 contains a Testing Schedule for the project. The table has been updated as a result of recommendations in the 5<sup>th</sup> Interim Report. Calcium Chloride was not recommended as a stabilizing agent due to low structural readings and the high incidence of pavement distress. As a result, CaCl<sup>2</sup> Leaching tests have been discontinued. Cross Section and Profile Elevation measurements exhibited little change in six years and have also been discontinued. According to the revised Test Schedule, roughness, rut depths, pavement deflections and crack survey data were obtained for this report.

Table 1  
Testing Schedule for Cyr – Van Buren  
Field Trial of Gravel Stabilization Methods

Year	ARAN Ride (IRI)	ARAN Rut Depth	Pavement Deflection	Elevation X- Sections	Elevation Profile	Crack Survey	CaCl <sub>2</sub> Leaching
1991	*	*	*				
1992	*	*	*	*	*	*	
1993	*	*	*	*	*	*	
1994	*	*	*				
1995	*	*	*	*	*	*	*
1996	*	*	*				
1997	*	*	*	*	*	*	
1998						*	
1999	*	*	*			*	
2000						*	
2001	*	*	*			*	
2002						*	
2003	*	*	*			*	
2004						*	
2005	*	*	*			*	
2006						*	

### Ride Summary

The Automatic Road Analyzer (ARAN) test vehicle was replaced in 1998 with an updated ARAN. The new ARAN was utilized to measure roughness; this is an ASTM Class II profiler using lasers to measure the vehicle's height above the road surface and accelerometers to measure vertical forces caused by surface deformities. Measurements are recorded every two inches in each wheel path. Data was collected on October 30, 2002 and September 3, 2003. Results are graphically presented in Figure 2 using International Roughness Index (IRI) values.

The Standard Subbase section continues to have the smoothest ride with average IRI values of 68.52 and 73.56 inches/mile (1.08 and 1.16 m/km) in 2002 and 2003 respectively, an increase of 13 % since 2001.

All three stabilized sections have slightly higher or lower average IRI values over the two year period. IRI values in the Soil Cement section increased from 91.26 (1.44) in 2001 to 93.75 (1.48) in 2002 and 97.55 (1.54) in 2003 a total increase of 6.9 %. Ride numbers in the Asphalt and Calcium Chloride sections increased between years 2001 and 2002 then decreased in 2003. Ride values in the Asphalt Stabilized section increased 7.7 % and the Calcium Chloride Section decreased 1.5 % between 2001 and 2003. It appears that ride values in the stabilized sections have remained somewhat stable over the past three years.

The Modified Subbase section continues to have the roughest ride with IRI numbers of 111.62 (1.76) in 2002 and 115.52 (1.82) in 2003, a total increase of 7.4% since 2001.

Statistical analysis of 2002 and 2003 IRI data using Tukey's Studentized Range (HSD) Test shows no significant difference between each section. Changes in IRI values are very small and all sections continue to be in the smooth range of 0 – 190 inches/mile (0 – 3.0 meters/kilometer).

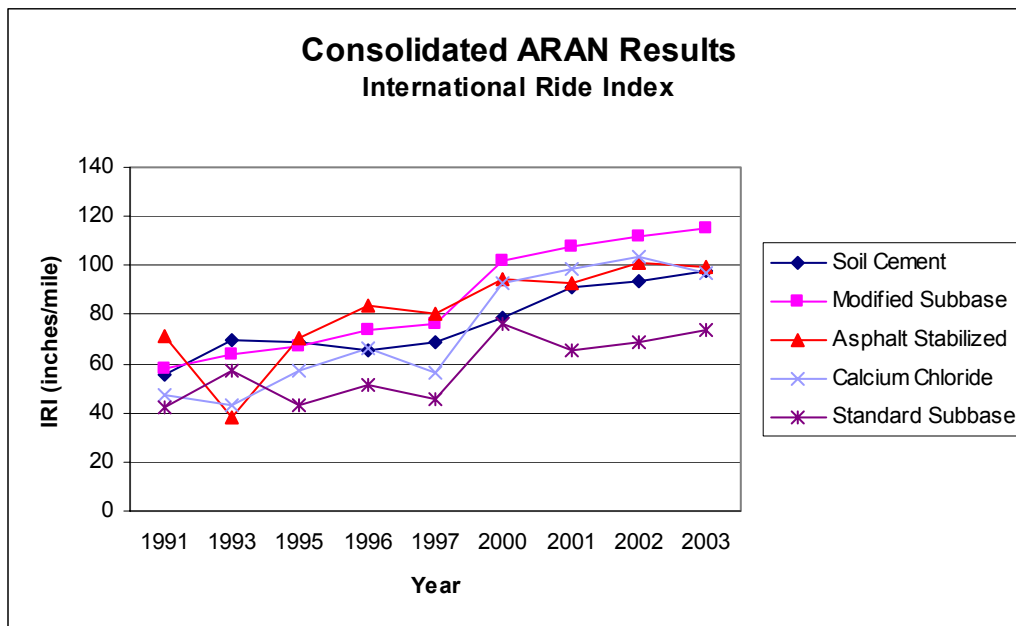


Figure 2. Ride Summary

### Rut Depth Summary

The ARAN test vehicle was also utilized to measure rut depths. The ARAN calculates rut depths in real time using ultrasonic sensors spaced 4 inches (102 millimeters) apart on a bar that traverses the width of the travel lane. Rut depths are collected by measuring the distance between the bar and road surface creating a transverse profile of the roadway at 50 foot (15 meter) intervals. Figure 3 contains a graphical display of the test results.

Rut Depths in 2002 have increased slightly in all but the Modified section which decreased in depth from 0.334 to 0.309 inches (8.5 to 7.8 mm), a difference of 7.5%. Rutting in all sections decreased slightly in 2003. Rut depth measurements are very similar in 2003 ranging between a high of 0.269 to a low of 0.240 inches (6.8 to 6.1 millimeters). Statistical analysis of the 2002 and 2003 Rut Depth Data indicates no significant difference between sections.

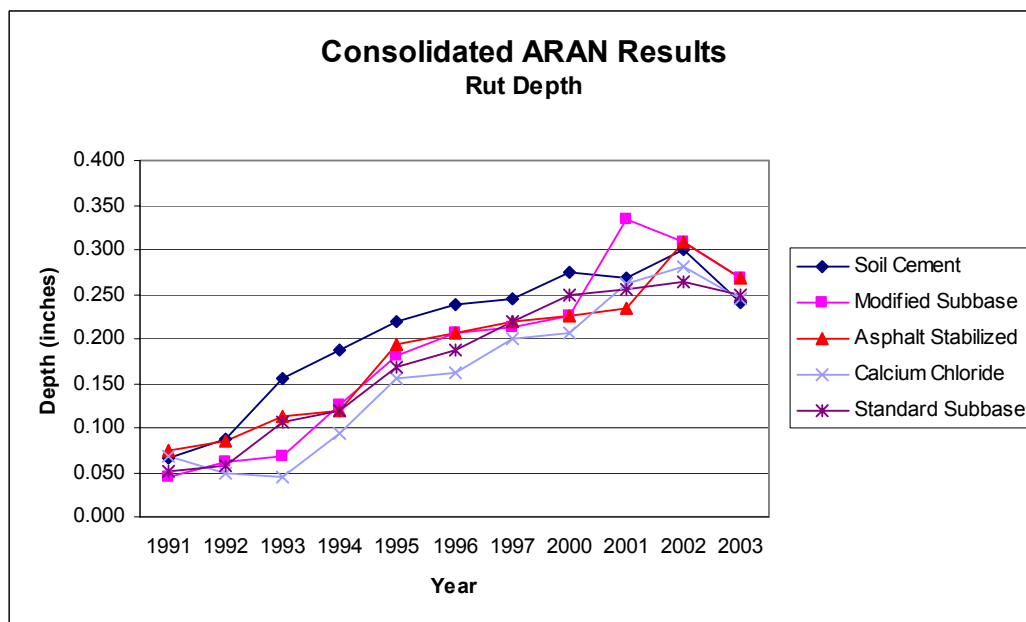


Figure 3. Rut Depth Summary

### Pavement Deflection Summary

Structural conditions were measured using two different test vehicles, the Road Rater and the Falling Weight Deflectometer (FWD).

The Road Rater was used from 1991 to 1996. This test vehicle has five sensors that measure pavement deflections as a weight vibrates the pavement at a specific frequency. The results are displayed in Figure 4 as an overlay required which is the depth of overlay necessary to restore each section to a 20 year design life using 24 inches (610 millimeters) of subbase and 6 inches (153 millimeters) of bituminous pavement, the lower the number the stronger the section. All readings are negative suggesting no overlay is necessary.

During this time period the Calcium Chloride, Modified Subbase, and Standard Subbase sections were structurally similar. The Asphalt Stabilized section has improved stability and the Soil Cement section has the greatest stability.

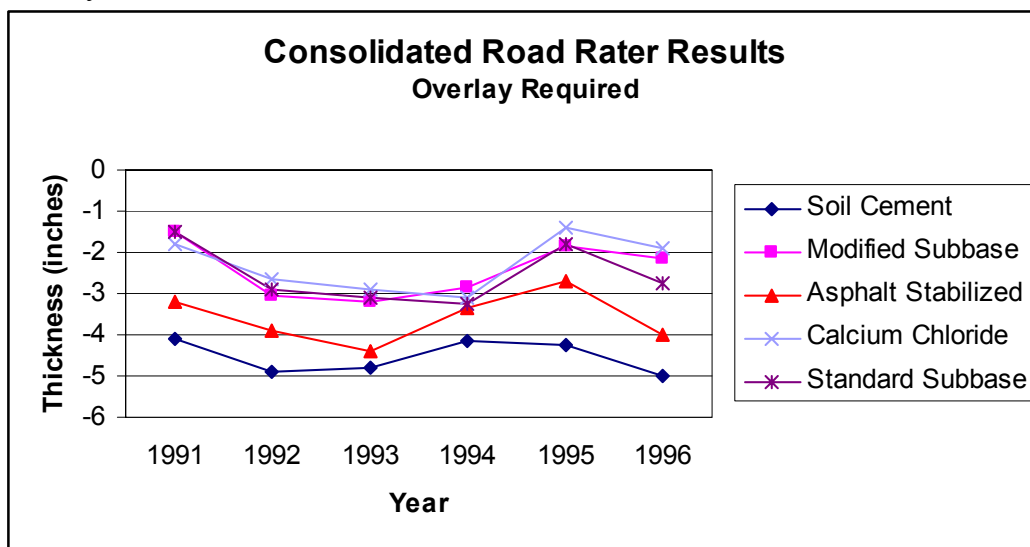


Figure 4. Road Rater Summary

The FWD also measures pavement deflections. This unit drops a weight onto a platform that is resting on the pavement, creating deflections that are recorded by seven sensors extending away from the platform. Pavement deflections indicate the structural stability of the roadway to a depth of 5 feet (1.5 meters). FWD deflections were recorded on August 18, 2003 and results are displayed in Figure 5 as an effective existing pavement structural number (SNeff) for 24 inches (610 millimeters) of subbase and 6 inches (153 millimeters) of bituminous pavement combined, the higher the number the stronger the section. Similar roadways of this design have structural numbers between 5 and 6.

Structural Numbers for all sections are proportionally lower than the previous test period indicating weaker subbase conditions. As has been the case throughout the evaluation period, the Calcium Chloride, Modified and Standard Subbase sections continue to be structurally equal. The Asphalt Stabilized section has greater stability than the previously mentioned sections and the Soil Cement section continues to outperform all other test sections.

A statistical analysis of FWD data is presented in Appendix A. Data reveals a significant difference when comparing Soil Cement and Asphalt stabilized sections to the Modified, Calcium Chloride, and Standard

Subbase sections and a significant difference comparing the Asphalt Stabilized and Standard Subbase to the Calcium Chloride and Modified Subbase sections.

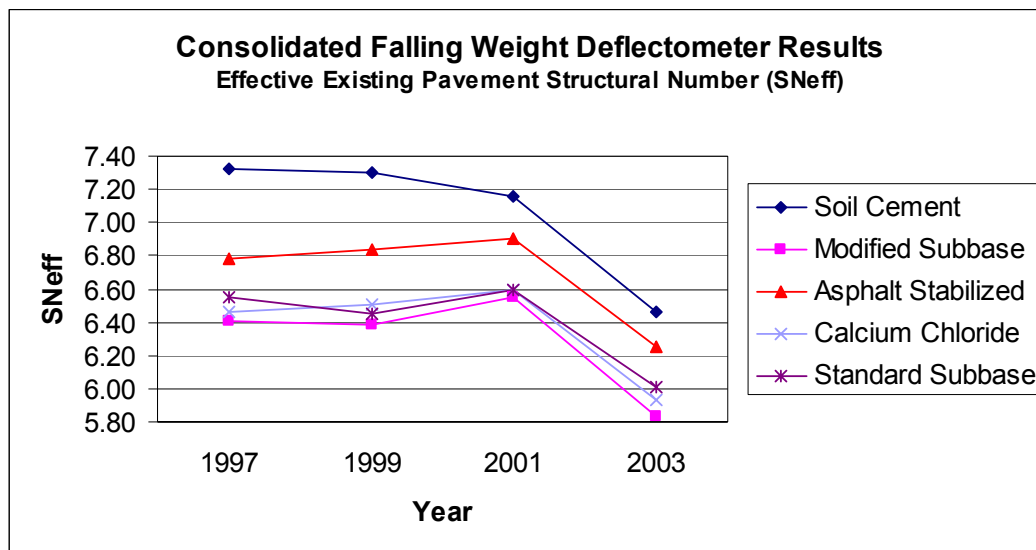


Figure 5. Falling Weight Deflectometer Summary

### Crack Survey Summary

A visual inspection of the project was conducted on September 26, 2002 and September 11, 2003. No additional cracks were observed during the 2002 inspection but a small increase in the amount of transverse and shoulder joint cracking was observed during the 2003 inspection. All of the cracks, with exception of the additional cracking observed in 2003, have been crack sealed. Photos of each section are included at the end of this report.

Asphalt flushed areas have remained the same since the last evaluation in 2001. One area is 45 feet (13.7 meters) in length between stations 1032+00 and 1033+00. The asphalt has pooled at centerline on the inner wheelpath and is flowing to the shoulder in the outer wheelpath (Photo 6). The asphalt is 0.5 inches (13 millimeters) thick in some areas. Flushing is not isolated to the Asphalt Stabilized section only. The Soil Cement, Modified Subbase, and Standard Subbase sections have areas of flushing 1 to 10 feet (0.3 to 3 meters) in length that are less severe. The Calcium Chloride section has no flushed asphalt areas. Core samples will be cut in 2005 to help determine the cause.

The Modified Subbase, Asphalt Stabilized and Calcium Chloride stabilized sections have full length centerline joint separation. The Soil Cement section has 92 feet (28 meters) of centerline separation and the Standard Subbase section has a total of 170 feet (52 meters) of centerline cracking.

All sections have shoulder joint separation. Cracking in the Asphalt Stabilized section has increased from 280 feet to a total of 320 feet (85 to 98 meters). The Modified Subbase, Soil Cement, Calcium Chloride, and Standard Subbase sections have no additional shoulder joint separation and remain at a total length of 182, 175, 153, and 192 feet (55, 53, 47, and 59 meters) respectively.

The Modified Subbase and Calcium Chloride sections each have one full width transverse crack. The Soil Cement section has two full width transverse cracks, two 4 foot (1.2 meter) cracks across centerline at station 1028+80 and 1029+12, and an additional 5 foot (1.5 meter) transverse crack across centerline at station 1029+30 that was observed in 2003. The Asphalt Stabilized area has three transverse cracks; one

full width, one three quarters across the lane, and a half width crack in the southbound lane. The Standard Subbase section has two full width cracks and a 4 foot (1.2 meter) crack at station 1037+40.

Longitudinal cracking between wheel paths remained the same with a total of 160 feet (49 meters) in the Calcium Chloride section and 5 feet (1.5 meters) in the Soil Cement section. No other sections are experiencing cracking of this type.

Load associated cracking was not observed within the experimental project.

## **Conclusion**

Smoothness and Rut Depth measurements are normal for a project of this age and there is no significant difference in values between sections.

Structurally, the Soil Cement and Asphalt Stabilized sections continue to outperform all other sections. Although pavement cracking is high for these sections, both treatments are supporting the roadway better than the remaining treatments.

Based on Structural Numbers, the Modified Subbase and Calcium Chloride sections are not supporting the roadway as well as the remaining sections and are not considered to be a viable subbase material.

The Standard Subbase (Control) section continues to perform slightly better than the Modified Subbase and Calcium Chloride sections but native soils in this area have a history of poor degradation and in time this section may perform poorly.

The next Interim Report will cover the period from January 2004 to December 2005. Additional tests to determine the cause of asphalt flushing will be included.

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### **Additional Available Documents:**

Field Trial of Gravel Stabilization Methods, Construction Report # 92-34, December 1991

First Interim Report, May 1993

Second Interim Report, February 1995

Third Interim Report, January 1996

Fourth Interim Report, January 1997

Fifth Interim Report, May 1998

Sixth Interim Report, September 2000

Seventh Interim Report, June 2003

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APPENDIX A  
STATISTICAL ANALYSIS of FWD MEASUREMENTS  
The SAS System  
The GLM Procedure

Class Level Information

<u>Class</u>	<u>Levels</u>	<u>Values</u>
group	5	AS CC MS SC SS

Number of observations 60

Dependent Variable: TESTs

<u>Source</u>	<u>DF</u>	<u>Sum of Squares</u>	<u>Mean Square</u>	<u>F Value</u>	<u>Pr &gt; F</u>
Model	4	3.17677667	0.79419417	12.10	<.0001
Error	55	3.60891667	0.06561667		
Corrected Total	59	6.78569333			

<u>R-Square</u>	<u>Coeff Var</u>	<u>Root MSE</u>	<u>TESTs Mean</u>
0.468158	4.209424	0.256158	6.085333

<u>Source</u>	<u>DF</u>	<u>Type I SS</u>	<u>Mean Square</u>	<u>F Value</u>	<u>Pr &gt; F</u>
group	4	3.17677667	0.79419417	12.10	<.0001

<u>Source</u>	<u>DF</u>	<u>Type III SS</u>	<u>Mean Square</u>	<u>F Value</u>	<u>Pr &gt; F</u>
group	4	3.17677667	0.79419417	12.10	<.0001

Tukey's Studentized Range (HSD) Test for TESTs

NOTE: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	55
Error Mean Square	0.065617
Critical Value of Studentized Range	3.98855
Minimum Significant Difference	0.2949

Means with the same letter are not significantly different.

<u>Tukey Grouping</u>	<u>Mean</u>	<u>N</u>	<u>group</u>
A	6.4517	12	SC – Soil Cement
A			
B A	6.2392	12	AS – Asphalt Stabilized
B			
B C	5.9950	12	SS – Standard Subbase
C			
C	5.9267	12	CC – Calcium Chloride
C			
C	5.8142	12	MS – Modified Subbase



Photo 1. 2002, Soil Cement Section



Photo 2. 2002, Modified Subbase Section



Photo 3. 2002, Asphalt Stabilized Section



Photo 4. 2002, Calcium Chloride Section



Photo 5. 2002, Standard Subbase Section



Photo 6. 2002, Asphalt Stabilized Section, Asphalt Flushed Area





Photo 7. 2003, Soil Cement Section



Photo 8. 2003, Modified Subbase Section



Photo 9. 2003, Asphalt Stabilized Section



Photo 10. 2003, Calcium Chloride Section



Photo 11. 2003, Standard Subbase Section